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THE MUDDY AND QUITCHUPAH PROJECTS:
A progress report with descriptions
of cores of the I, J, and C coal beds from the Emery coal
field, central Utah

By
Thomas A. Ryer

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Abstract

The Muddy and Quitchupah Projects recovered 24 cores of the I, J, and C coal beds in the central and northern parts of the Emery coal field, central Utah. The cores are described herein. Material from the cores will be analyzed to determine coal quality, major, minor and trace element geochemistry, mineralogy of ash, coal petrography, and palynology, plus mineralogy of layers of altered volcanic ash contained in the coal.

Introduction

Rotary drilling and coring of selected intervals within coal-bearing strata of the Ferron Sandstone Member of the Mancos Shale in the Emery coal field, central Utah, was undertaken by the USGS during the late spring and early summer months of 1979 and 1980. The drilling and coring were accomplished under two distinct projects, informally named the Muddy Project (1979) and the Quitchupah Project (1980). This report includes descriptions of the cores recovered and briefly describes the purposes of the two drilling projects.

Purpose

The Emery coal field, with total coal resources of approximately 1.4 billion short tons (Lupton, 1916; Doelling, 1972), is one of the smaller coal fields in the state of Utah. It combines, however, a variety of characteristics that make it a nearly ideal area for conducting studies interrelating the original depositional settings of the coal beds with their areal distribution, palynology, petrology, and geochemistry. Exposures of the Ferron Sandstone Member in the Emery area are excellent, facilitating detailed stratigraphic

study. The structural strike of the area is at a high angle to the trend of the Ferron (Cretaceous, late Turonian) shoreline, making possible the delineation of the full extent of individual deltaic cycles within the Ferron. Also, the area has been extensively drilled by industry. Though most of these subsurface data remains proprietary, they, together with data gathered during field studies, have been synthesized to produce a genetic model for the thicker coal beds in the Emery coal field (Ryer, 1979, 1980). Many of the coal beds in the Emery coal field contain partings of altered volcanic ash called tonsteins. Though the thickest of these partings may lower the value of the coal by increasing the ash content, they are valuable in stratigraphic studies as time lines, enabling correlation of units within individual beds of coal. This enables reconstruction of the depositional histories of some of the coal beds at a level of refinement that would otherwise be impossible (Ryer and others, 1980).

The depositional models developed for the I, J, and C coal beds of the Emery coal field are the most complete, and these beds were targeted for coring. The 3-inch-diameter cores recovered from these coal beds during the course of the Muddy and Quitchupah Projects were distributed to various individuals in the USGS for study of coal petrology, coal quality, major, minor, and trace element geochemistry, mineralogy of coal ash, mineralogy of tonsteins, and palynology. The ultimate objective of the Muddy and Quitchupah Projects is the determination of genetic relationships between the paleo-environmental histories of the I, J, and C coal beds and the physical and chemical properties of the coal that they contain, as determined through the disciplines cited above. It is anticipated that such relationships can play an important part in predictive modeling of Cretaceous coal beds in the Western Interior United States.

Acknowledgments

Because of the special nature of the drilling projects, it was essential that recovery of cores be as complete as possible, with a minimum of breakage. Cores of exceptional quality were recovered by Art Clark, driller, and his special attention to careful drilling and handling of the cores is greatly appreciated. Steve Grant drilled three of the Quitchupah Project cores. Anna Langer, Fred Simon, and Ron Affolter served as geologists during parts of the drilling projects, and Robert Hobbs, Warren Teasdale, and Richard Babcock coordinated the drilling. W. A. Cobban identified the mollusks collected from core holes Q-5a and Q-13.

Many of the holes were drilled in coal owned or leased by the Consolidation Coal Company. Personnel from that company made available all of their proprietary subsurface information for the area, which was essential in developing the depositional models upon which the drilling projects were based. The continuing support of William Eastwood, geologist in charge of the Emery area, is gratefully acknowledged. Additional subsurface data in the northernmost part of the Emery coal field was supplied by Jerry Vaninetti, Utah Power and Light Company.

Muddy Project

Drilling and coring for the Muddy Project, named for the nearby canyon of Muddy Creek, was completed during May and June, 1979. Ten holes, designated M-1 through M-10, were drilled. Their locations are shown on Figure 1. The holes, spaced at intervals ranging from about 1,500 to about 4,000 feet, constitute, in ascending numerical order, a landward-to-seaward-transect across the seaward edge of the swamp in which material of the I and J coal beds accumulated. The J coal bed represents seaward (northeastward) extension of the swamp that earlier produced the I coal bed. The I coal bed reaches its

greatest thickness in the southwestern holes of the Muddy Project; the J coal bed reaches its greatest thickness in the northeastern holes. Figure 2 is a cross section incorporating data from holes of the Muddy Project, proprietary drill-hole data obtained from the Consolidation Coal Company (numbers and locations of the holes not shown), and stratigraphic sections measured on natural exposures in the northern part of the canyon of Muddy Creek (S-1 through S-6; locations shown on Fig. 1).

A terminology problem exists. In the vicinity of hole M-1, Lupton (1916), who first applied alphabetical designations to the coal beds of the Emery coal field, called the thick bed of coal "coal bed I." He correlated this coal with the coal bed formerly mined at the Williams Mine (measured section S-6), calling it, too, "coal bed I." It is true that these two beds of coal occur at about the same stratigraphic level, the J thinning southwestward and eventually merging with the I. However, the I and J coal beds accumulated during two successive cycles of sedimentation within the deltaic system that produced the Ferron Sandstone Member (Ryer, 1980). Along other parallel lines of section constructed using subsurface data, the two coal beds do not join. Accordingly, the coal bed cored in core hole M-10 and the upper parts of M-6 through M-9 is referred to as J; the splits cored in core holes M-7, M-8, and M-9 are viewed as splits of the I; and the thick coal bed in holes M-1 through M-5 is regarded as combined I-J, though the J makes up only a small, undetermined amount of coal at the top of the bed. This usage conforms to that of the Consolidation Coal Company.

Figure 2 shows that the I and J coal beds taken together are consistently 25 or more feet thick in holes M-1 through M-5, the only significant parting being the tonstein in the upper part of the bed. Northeast of hole M-5, however, the coal bed splits, the coal interfingering with fluvial and lagoonal

or bay deposits. The uppermost split continues northward, and is recognized as the J coal bed in the northern part of the area.

It must be noted that Lupton's correlation of and designation scheme for coal beds in the Emery coal field, though excellent for its time, is now outdated. His correlations of the major coal beds (beds A, C, G, and I), with few exceptions, are correct. Many of the minor coal beds, which he assigned separate letter designations and sometimes correlated for great distances, are, in fact, locally developed rider seams or subseams of the major coal beds (for instance, Lupton referred to the northeasternmost split of the I coal bed, shown in S-3, S-4, and S-5, as "coal bed H"). It might be advisable, in the future, to develop a new designation scheme for the coal beds of the Emery coal field, perhaps utilizing the names of old mines or geographic names for the beds rather than letters of the alphabet.

The stratigraphic situation depicted in Figure 2 offers an opportunity to study the variations in the physical and chemical properties of a coal bed as it approaches the seaward margin of original peat accumulation. The upper subseams of the I coal bed interfinger with heavily bioturbated silts and sands deposited in a marginal-marine bay or lagoon. The tops of many of the subseams themselves have been burrowed, clear evidence that they were once exposed directly to the effects of marine or brackish waters.

Quitichupah Project

Core holes of the Quitichupah Project, named for nearby exposures in the canyon of Quitichupah Creek, were drilled during April, May, and June of 1980 (Fig. 1). Locations originally designated Q-1 and Q-2 were not drilled; one location (Q-5, 5a) was redrilled; and another (Q-10, 10a) was moved and redrilled in another location for a total of 14 core holes (see explanations accompanying descriptions of core). The locations of core holes Q-5, Q-10,

and Q-11 coincide with those of M-1, M-5, and M-9, respectively. In these holes, the I and J coal beds were cored to provide additional material for use in study of the Muddy Project cores. All of the Quitchupah Project holes, with the exception of Q-10, cored the C coal bed. Hole Q-10a was drilled at the location of hole M-6, 6c, though the I-J coal bed was not cored. The cores of the C coal bed, with the exception of Q-5, are shown on Figure 3, a fence diagram constructed as though the viewer were looking towards the WNW and downward at an angle of 30°.

The holes of the Quitchupah Project are situated along a NNE trend that is approximately parallel to the structural strike of the area. As is the case for the Muddy Project, this trend is at a high angle to the paleoshoreline, seaward being towards the northeast. While the Muddy Project was designed to sample, at closely-spaced intervals, just the seaward margin of a peat-accumulating basin, the Quitchupah Project represents a nearly complete, though more widely-spaced, sampling across such a basin. At the southwestern edge of the area, the C coal bed interfingers with fluvial strata. At the northeastern edge of the area the coal becomes shaley, the coal bed thinning and pinching out still farther northeastward, as indicated by proprietary subsurface data supplied by Utah Power and Light Company and by outcrop data.

The depositional history of the C coal bed has been described in considerable detail elsewhere (Ryer and others, 1980) and will not be repeated here. The C coal bed contains 4 distinctive tonstein partings: an upper, thick parting, referred to here simply as "thick"; a middle pair or doublet of thin partings, referred to as the "doublet"; and a lower parting, referred to as "lower." These partings, which constitute time surfaces or, in sections, time lines, are used in Figure 3 to divide the C coal bed into 4 isochronous,

or nearly isochronous units. The series of cores recovered from the Quitchupah Project drilling afford an opportunity to study lateral variations in coal petrography, palynology, coal quality and geochemistry, as well as variations in composition of ash within isochronous coal units. Lateral variations in the mineralogy of the tonsteins themselves will also be studied. The roof rocks of the C coal bed vary dramatically in composition within the area of the Quitchupah Project. At location Q-6 and northeast of it, the coal bed is erosionally overlain by a prograded delta-front sandstone unit. To the southwest, it is overlain by bay and fluvial deposits, an ideal stratigraphic situation in which to examine the influence of marine and brackish water on the chemistry of peat prior to its coalification to form the coal of the C coal bed.

Description of cores

Abbreviations used in descriptions:

ss - sandstone

sltst - siltstone

sh - shale

clyst - claystone

sdv - sandy

slty - silty

shy - shaley

carb - carbonaceous

c-gr - coarse-grained

med-gr - medium-grained

f-gr - fine-grained

vf-gr - very fine grained

x-bedded - crossbedded

lam - laminated or laminae

interlam - interlaminated

frags - fragments

grad - gradational

M-1 NE 1/4 sec 33, T. 22 S., R. 6 E. approx. 2,000' from E line,
500' from N line of section

Lat 38° 51'54" N., long 111° 15'00" W.

100-101.2: sltst, sdv; irregular lam; finely divided coaly frags

101.2-125.0: ss, generally med-gr, f-gr and c-gr in some parts; x-bedded;
mdst chips and finely divided plant frags at several levels;
bottom 0.5' contains frags of coal; basal contact sharp
(active channel-fill sequence)

125.0-126.3: sh, carb

126.3-128.2: ss, very heterogeneous; frags of coaly sh; lowermost 1' contains wavy lam of sltst and is heavily burrowed; basal contact sharp

128.2-155.1: I-J coal bed

uppermost 0.6' shly coal

carb sltst 0.05 @ 128.85

128.85-129.45 shly coal

tonstein 0.05 @ 129.5

129.5-131.45 coaly sh and shly coal

tonstein 0.05 @ 131.5

132.3-132.8 shly coal

132.8-133.0 carb sh

tonstein 0.6 @ 133.6; upper half clean clyst, lower half coaly

tonstein 0.02 @ 139.55

tonstein thin lenses @ 140.1

155.1-155.5: sh, slty, carb, coaly streaks

155.5-161.8: ss; uppermost 1' very slty; contorted lam of siltst; rooted (probably represents uppermost part of channel-fill sequence)

TD 161.8

M-2 SE 1/4 sec. 28, T. 22 S., R. 6 E., approx 700' from E line, 1,000' from S line of section

Lat 38°52'08" N., long 111°14'42" W.

98.2-106.3: ss, f-gr; a few lam of finely divided plant frags; heavily burrowed throughout; a few distinct Ophiomorpha; basal contact sharp (lower part of marine sandstone unit)

106.3-132.6: I-J coal bed
 uppermost 0.4' contains lenses of slty shale and ss-filled
 burrows; tonstein 0.1 @ 108.1, diffuse in coal; tonstein 0.25 @
 111.9; rooted; upper part carb

132.6-132.8: sh, carb

132.8-134.0: clyst

134.0-136.1: sltst, cly grading downward to ss, vf-gr, slty,
 rooted (probably represents uppermost part of channel-fill
 sequence)

TD 136.1

M-3 SW 1/4 sec. 27, T. 22 S., R. 6 E., approx 400' from W line, 2,300'
 from S. line of section

Lat 38°52'21" N., long 111°14'27" W.

116.0-117.5: ss, f-gr; x-bedded; basal contact sharp (probably lowermost
 part of active channel-fill sequence)

117.5-139.1: ss, f-gr; contorted lam of finely divided plant frags in
 upper part; burrowed, the number of burrows generally
 decreasing downward; x-bedded in lower part; basal contact
 sharp (lower part of marine sandstone unit)

139.1-139.5: sltst, coaly; ss-filled burrows at top

139.5-164.1: I-J coal bed
 tonstein? 0.01 @ 141.2
 tonstein 1.3 @ 144.0; carb in upper part; grad upper, sharp
 (lower contact)
 tonstein 0.1 @ 149.2 tonstein, thin streaks
 between 150.3 and 150.6

164.1-164.5: sh, coaly

164.5-166.0: clyst, basal contact grad

166.0-167.2: clyst, slty

TD 167.2

M-4 NW 1/4 sec. 27, T. 22 S., R. 6 E., approx. 2,400' from W line, 1,600'
from N line of section

Lat 38°52'34" N., long 111°14'01" W.

Core begins in coal, the coring point having been picked too low,
though probably no more than few tenths of a foot of coal was lost
to drilling.

85.0-109.8: I-J coal bed

89.1-90.4 clyst, sdy, carb; increasingly carb and sdy towards top

90.4-91.9 tonstein

tonstein 0.15 @ 97.3

tonstein, thin streak @ 97.5

tonstein, thin streak @ 97.6

109.8-113.1: sltst, carb; coaly frags, the number of frags decreasing
downward; upper half rooted; lowermost 1' cly

TD 113.1

M-5 NE 1/4 sec. 27, T. 22 S., R. 6 E.

approx 1,100' from E line, 800' from N line of section

Lat 38°52'42" N., long 111°13'39" W.

75.0-79.4: ss, f-gr; minor finely-divided plant frags; mostly planar
lam, some x-bedding; basal contact sharp, irregular (lower
part of marine sandstone unit)

79.4-103.8: I-J coal bed

tonstein 0.8 @ 83.7; upper 1/3 coaly; basal contact very irregular
tonstein, lenses up to 0.1 @ 89.7

tonstein 0.2 @ 91.0; upper half coaly

103.8-104.2: ss, f-gr, white; contorted lam

104.2-104.3: sh, coaly

104.3 104.6: sltst, carb, with two thin, contorted beds of vf-gr ss

104.6-105.3: sltst, cly; coaly frags; rooted

105.3-113.7: ss, vf-gr; uppermost 2' massive, rooted; lam of clyst and
sltst, the number of lam decreasing downward (probably upper
part of channel-fill sequence)

TD 113.7

M-6/6c NW 1/4 sec 26 T. 22 S, R. 6 E. hole located right in NW corner of
section, within 50' of N and W lines of section

Lat 38° 52' 50" N., long 111° 13' 24" W.

A number of both geological and mechanical problems were encountered in the
course of drilling this hole. As a result, a single complete core was not
obtained. Instead, two overlapping cores were obtained. They may be correlated
using the pair of tonsteins that occur at depths of 94.3 and 96.2 in core
M-6 and at 92.1 and 93.0 in core M-6c.

M-6

81.7-82.4: ss, f- to med-gr; basal contact sharp (lower part of marine
sandstone unit)

82.4-82.8: sh, coaly; contains ss-filled burrows

82.8-84.6: J coal bed

tonstein 0.4 @ 83.1

tonstein 0.1 @ 83.8

84.6-84.8: sh, slty; coaly frags

84.8-85.0: ss, vf-gr, slty; burrowed

85.0-85.1: sh, carb

85.1-85.8: ss, vf-gr, slty; coaly frags; clyst lam; a few small-diameter burrows; pyrite nodules at base

85.8-86.0: clyst, slty with lam of vf-gr ss; burrowed; pyrite nodules at base (interval 84.6-86.0 represents the landward edge of a bayfill or lagoonal deposit)

86.0-102.1: upper part of I coal bed
tonstein 1.5 @ 88.2; upper part carb

91.0-91.8: upper part sh, coaly; lower part vf-gr ss with coaly streaks and frags; basal contact sharp, irregular
tonstein 0.1 to 0.2 @ 94.3
tonstein 0.1 to 96.2

TD 102.1

M-6c

90.0-106.3: lower part of I coal bed
tonstein 0.2 @ 92.1
tonstein 0.05 @ 93.0
coaly sh 0.4 @ 104.7; a ss-filled burrow now greatly contorted by compaction extends downward from this parting to a depth of 105.0

106.3-107.6: clyst; coaly frags

107.6-111.0: sltst; rooted; faint horizontal banding

111.0-115.9: sltst with clyst lam; some soft-sed deformation and micro-faulting; burrowed

TD 115.9

M-7 SW 1/4 sec. 23, T. 22 S., R. 6 E., approx. 1,400' from W. line,
1,100' from S line of section

Lat 38°53'01" N., long 111°13'06" W.

- 63.0-64.1: ss, f-gr; x-bedded; minor finely-divided plant frags (lower part of marine sandstone unit)
- 64.1-64.5: sh, coaly; ss-filled burrows at top
- 64.5-66.4: J coal bed
- 66.4-66.7: core lost
- 66.7-66.8: clyst
- 66.8-67.1: sltst; coaly lenses; lower contact gradational
- 67.1-68.9: ss, vf-gr with contorted lam of sltst grading downward to sltst; burrowed throughout; carb at bottom (bay-fill or lagoon-fill sequence)
- 68.9-92.1: I coal bed
- 68.9-69.2 coal with lenses of carb shale and masses of pyrite
- 69.2-69.8 shly coal
- tonstein 0.5 @ 70.3
- 72.4-72.8 carb sh with coaly streaks
- 72.8-73.3 carb sh with lam of vf-gr ss
- 73.3-73.6 ss, vf-gr with many lam of clyst and sltst; burrowed
- 73.6-74.8 carb sh
- 74.0-74.8 ss, as above; basal contact sharp
- (parting 72.4-74.8 represents bay-fill or lagoonal deposits)
- tonstein? 0.01 @ 78.5
- lens of vf-gr ss up to 0.1 @ 82.5
- 88.65-88.9 sdy coal with ss-filled burrows
- 92.1-93.5: sltst; coaly frags

93.5-95.8: clyst, slty

TD 95.8

M-8 Just south of quarter section line separating NE and SE quarters of
sec. 23, T. 22 S., R. 6 E.; approx 2,000' from E line, 2,700' from N
line of section

Lat 38°53'16" N., long 111°12'43" W.

25.0-32.1: ss, vf-gr; planar lam and x-bedded; soft-sed deformation;
heavily impregnated with pyrite at base; basal contact sharp
(lower part of marine sandstone unit)

32.1-33.8: J coal bed; coal is shly

33.8-34.9: sh, coaly, basal contact gradational

34.9-38.5: a generally upward-coarsening sequence; upper part vf-gr
ss with lam of sltst grading downward to cly sltst with lam
of vf-gr ss; entire interval heavily burrowed (bay-fill or
lagoonal deposits)

38.5-49.7: split of I coal bed
lenses of carb sltst in uppermost 0.5'
tonstein 0.05 @ 41.0

41.6-41.8 shly coal

41.8-42.4 coaly sh
tonstein 0.15 @ 42.6

42.6-43.6 shly coal

43.3-43.6 coaly sh with masses of pyrite

45.9-46.1 carb sh

46.1-47.3 ss, vf-gr, silty; contorted lam of clyst and sltst; lots of
finely-divided plant frags; heavily rooted

47.3-47.4 carb sltst

47.4-47.9 shly coal, burrowed at top
 49.3-49.7 shly coal
 49.7-49.9: sltst, carb
 49.9-56.8: upward-coarsening sequence as described above (bay-fill or lagoon deposit)
 56.8-61.4: subseam of I coal bed
 lenses of carb sh in upper part
 58.9-59.5 ss, vf-gr with lam of clyst; lam contorted; minor burrowing
 61.4-62.2: sh, carb, slty in upper part
 62.2-63.3: clyst, slty
 63.3-65.4: sltst, sdy; minor rooting
 65.4-68.1: clyst; carb at bottom
 68.1-68.7: subseam of I coal bed
 68.7-68.8: sh, carb
 68.8-71.4: clyst, coaly in upper part
 71.4-72.3: sltst, cly
 72.3-76.0: ss, vf-gr, slty; contorted lam of sltst; rooted (probably top of channel-fill sequence)

TD 76.0

M-9 NE 1/4 sec. 23, T. 22 S., R. 6 E. approx. 1,000' from E line, 900' from N line of section.

Lat 38°53'34" N., long 111°12'30" W.

27.0-33.3: ss, vf-gr; planar lam, minor x-bedding; dispersed, finely divided plant frags; a few small shell frags; two zones of soft-sediment deformation; sltst lam in lower part

33.3-34.3: sltst with lam of clyst; ss-filled burrows in upper part

34.3-37.2: lost core; probably sltst and clyst

37.2-38.2: clyst, slty; masses of pyrite at bottom; basal contact sharp
(27.0-38.2 is lower part of marine sandstone unit plus upper offshore sltst and clyst)

38.2-39.7: sh, coaly; masses of pyrite; ss-filled burrows; tonstein 0.02 @ 38.65

39.7-43.5: J coal bed; masses of pyrite common

43.5-44.3: clyst with coaly streaks; slty in lower part

44.3-47.7: upward coarsening sequence; upper part vf-gr ss with contorted clyst lam; thickness and number of clyst lam increases downward; lowermost 1' clyst, slty; entire interval heavily burrowed (bay-fill or lagoonal sequence)

47.7-48.3: sltst, cly; masses of pyrite at bottom

48.3-49.1: coal with lenses of carb sh and masses of pyrite; totals approximately 50% coal

49.1-49.7: subseam of I coal bed

49.7-50.0: sh, carb

50.0-50.3: sltst, carb; heavily rooted

50.3-52.7: ss, vf-gr; abundant contorted lam of sltst; minor rooting; burrows in lowermost 1' (probably upper part of another bay-fill or lagoonal sequence)

TD 52.7

Total planned depth for this hole was 100'. The rig was moved off the location because of mechanical problems and could not reoccupy the site due to mud following beginning of irrigation. Only the uppermost of several subseams of the I coal bed present at this location was sampled.

M-10 SW 1/4 sec. 13, T. 22 S., R. 6 E. approx. 1,000' from W line, 2,300'
from S line of section

Lat 38°54'06" N., long 111°12'05" W.

20.6-22.6: ss, vf-gr with lam of sltst; burrowed; coal chips in lower part;
masses of pyrite at bottom; basal contact sharp (lower part
of shallow-marine bar deposit)

22.6-28.2: J coal bed
uppermost 0.5' shly;
ss-filled burrows at top
tonstein 0.01 @ 22.85; diffuse in coal

23.1-23.7 shly coal
lower half of coal bed has many masses of pyrite

28.2-28.4: sh, carb

28.4-29.2: clyst, slty

29.2-29.7: ss, vf-gr with lam of sltst; burrowed

29.7-30.4: sltst, cly

Q-2a Approx. on quarter section line separating NW and NE quarter of
sec. 20, T. 23 S., R. 7 E. Approx. 500' from N line of section.

Lat 38°48'24" N., long 111°16'11" W.

110.0-118.9: ss, f- to med-gr; x-bedded, lots of finely divided plant
frags; sharp basal contact (basal part of active channel-fill)

118.9-120.9: coal (probably a subseam or rider of the C coal bed)
tonstein 0.05 @ 119.25; dark, rusty gray

120.9-121.4: clyst, carb at top, grading downward to cly sltst

121.4-122.3: interbedded sltst and vf-gr ss; rooted

122.3-124.7: sltst, cly

(interval 120.9-124.7 represents fluvial flood basin deposits)

124.7-126.0: ss, vf- to f-gr with sltst lam; lots of finely divided plant material in upper part; ripple-drift x-lam (overbank splay deposit)

126.0-127.7: sltst, cly; a few lam of vf-gr ss (flood basin)

127.7-131.5: coal (subseam of C coal bed)

131.5-137.3: interbedded sltst and vf-gr ss; ss included some sltst rip-ups and ripple-drift x-lam; soft-sed deformation structures; minor rooting and possible burrowing near top; grad lower contact

137.3-140.2: sltst, cly and slty clyst; lam of vf-gr ss in upper part; (131.5-140.2 represent flood-basin deposits)

140.2-142.8: coal (subseam of C coal bed)

142.4-142.65 shly coal

142.8-144.1: Probable tonstein ("thick"); gradational lower contact

144.1-150.1: ss, vf-gr, slty with lam and beds up to 0.4' thick of sltst; rooted in upper part; ss displays ripple-drift lam in some places; sparse but distinct burrows; sharp basalt contact (distal part of overbank splay)

150.1-161.3: clyst and slty clyst; crumbly

TD 161.3

Q-3 SE 1/4 sec. 8, T. 23 S., R. 6 E. approx. 1,000' from E line, 200' from S line of section

Lat 38°49'23" N., long 111°15'50" W.

225.0-225.6: coal (lower part of G coal bed)

225.6-226.2: sh, coaly; grad lower contact

226.2-227.5: sh containing a few coal frags; grad lower contact

227.5-228.7: sltst, cly; clay content decreases downward; heavily rooted

(225.6-228.7 represents flood basin deposits)

228.7-229.3: interlam vf-gr ss and sltst; rooted; sharp basal contact
(distal part of overbank splay)

229.3-230.2: sltst, cly; contains finely-divided plant frags

230.2-232.4: clyst

(229.3-232.4 represents flood-basin deposits)

232.4-251.4: C coal bed

232.4-232.8 shly coal

possible thin lenses of tonstein @ 237.2

242.4-243.65 tonstein ("thick"); sharp basal, gradational upper contact;
rooted
tonstein 0.4 @ 246.6; diffuse in coal (probably upper member
of "doublet")

247.0-248.45 carb sh

248.45-249.45 coal, shly and coaly sh

tonstein 0.3' @ 249.75 ("lower"), grad contacts

251.4-252.0: sh, coaly; grad lower contact

252.0-253.0: sltst, shly; rooted

TD 253.0

Q-4 NW 1/4 sec. 4, T. 23 S., R. 6 E. approx. 1,000' from W line, 2,500'
from N line of section.

Lat 38°50'41" N., long 111°15'26" W.

210.0-210.5: sltst, cly and slty clyst; grad lower contact

210.5-215.3: ss, vf-gr; rooted at top; x-bedded; lowermost 0.5' incorporates
sltst lam and sltst rip-ups and shows some burrowing; basal
contact sharp with some ss-filled burrows extending down into
underlying unit (a small channel-fill or proximal splay deposit,

probably in a brackish-water, lower delta plain environment)

215.3-216.9: sltst, cly; contains sparse transported plant frags

216.9-217.6: clyst, slty, grading downward to carb sh and coaly sh

217.6-220.8: coal (probably the G coal bed)

tonstein 0.15' @ 218.35; sharp contacts

220.8-221.8: sh, coaly; grad lower contact

221.8-223.5: sh, carb

223.5-238.6: alternating cly sltst and vf-gr ss; heavily burrowed throughout; ripple-drift x-lam present in some of the ss where burrowing is less intense; ss content generally decreases downward; rooted at top; basal contact is abrupt but appears nonerosional (bay-fill sequence)

238.6-238.7: sh, coaly

238.7-240.2: coal (subseam or rider of the C coal bed)

240.2-240.4: sh, carb

240.4-241.9: sltst, cly, sdy in upper part; minor rooting at top; sparse plant frags; burrowing evident where sdy

241.9-244.9: upper half interlam vf-gr ss and sltst, sparse burrows, lots of finely divided plant frags; lower half sltst, sdy, heavily burrowed, many transported oyster shells, a few lenses and frags of coal (bay-fill sequence)

244.9-261.3: C coal bed

top 0.5' contains lenses of coaly shale

246.5-247.0 coaly sh

248.3-248.5 coaly sh

251.9-253.4 tonstein ("thick"); sharp basal, grad upper contact; some layering in lower part; minor rooting

tonstein 0.05 @ 255.7 (upper member of "doublet") diffuse in coal
tonstein 0.1 @ 257.0 (lower member of "doublet") sharp contacts
tonstein 0.4 @ 259.2 ("lower"); grad contacts with coal; darker,
more carb than usual

261.3-261.7: sh, carb; grad lower contact

261.7-263.3: sltst, cly; rooted; grad lower contact

263.3-265.0: interlam and interbedded vf-gr ss and sltst; rooted; possible
sparse burrows

TD 265.0

Q-5 NE 1/4 sec. 33, T. 22 S., R. 6 E., approx. 2,000' from E line, 500'
from W line of section

upper part twins M-1

Lat 38°51'54" N., long 111°15'00" W.

120.0-125.0: ss, f- to med-gr; x-bedded (basal part of active channel-fill
sequence)

125.0-125.6: sh, carb

125.6-126.2: clyst, slty; a few coal frags

126.2-127.5: ss, vf-gr, slty; ss-filled burrows; coal frags; masses of
pyrite at bottom

127.5-153.5: I-J coal bed

lenses of carb sh in uppermost 0.8'

tonstein 0.15 @ 128.7

carb sh 0.15 @ 129.9

tonstein 0.05 @ 130.6

tonstein 0.25 @ 132.0

tonstein, lenses up to 0.1 @ 138.2

tonstein 0.4 @ 138.8; diffuse in coal

153.5-154.2: sh, carb

154.2-154.6: clyst

154.6-155.0: sltst, cly

155.0-158.6: ss, vf-gr; slty in upper part; ripple drift lam in lower part
(probably upper part of channel fill sequence)

(interval 158.6 to 235.0 rotary drilled)

235.0-236.1: sh, coaly; there are a few small lenses of what appears to be
tonstein near the bottom

236.1-248.4: C coal bed

236.7-237.6 interval has a lot of rounded frags of fusinite

ss, vf-gr, containing rounded frags of coal 0.1 @ 241.3

tonstein 0.2 @ 243.5 (upper member of "doublet"); diffuse in coal

tonstein 0.1 @ 244.1 (lower member of "doublet"); diffuse in coal

tonstein 0.1 @ 245.95 ("lower")

248.4-248.6: sh, carb

248.6-250.0: clay, plastic

250.0-250.8: clyst, slightly slty

250.8-251.7: sltst, coarsening downward, incorporating some vf-gr ss near
base; sparse carb frags; sparse, faint burrows near base

TD 251.7

Q-5a Same location as Q-5

Hole Q5a was drilled because, with the absence of the "thick" tonstein
of the C coal bed in core Q-5, there was uncertainty as to whether
or not the entire coal bed had been recovered

219.0-221.7: Sltst, sdy; bioturbated; oyster shells in middle part; well-
preserved specimens of Veloritina sp. throughout, some of them
in life position

- 221.7-222.0: Oyster shells in a matrix of sdy sltst; many oysters bivalved and displaying little or no breakage - in situ assemblage (219.0-222.0 represents mud deposited in a bay or lagoon associated with the peak of transgression preceding the No. 4 delta cycle)
- 222.0-223.2: ss, f-gr with wisps of sltst, the sltst totals approx 30%; heavily bioturbated; sparse finely divided plant frags; grad lower contact
- 223.2-226.0: ss, vf- to f-gr; Ophiomorpha common; grad lower contact
- 226.0-233.2: ss, f-gr; heavily burrowed; many oyster frags in top 1'; abundant finely-divided plant frags, the size of the frags increasing downward to coal frags in bottom 2'; some of the larger coal frags contain ss-filled Teredolithus; sharp basal contact
(222.0-233.2 represents the landward edge of the No. 4 delta-front sandstone - specific environment of deposition not known)
- 233.2-234.6: sh, coaly
- 234.6-248.2: C coal bed
- 239.9-241.2 tonstein ("thick"); sharp basal, grad upper contact
tonstein 0.1 @ 243.25 (upper member of "doublet"); diffuse in coal
tonstein 0.1 @ 243.85 (lower member of "doublet"); diffuse in coal
tonstein 0.25 @ 245.75 ("lower"); sharp contacts
- 248.2-248.5: sh, coaly; grad lower contact
- 248.5-249.5: clyst; rooted; grad lower contact
- 249.5-250.9: sltst, cly at top; rooted in upper part; faint burrow mottling

near bottom

TD 250.9

Q-6 NW 1/4 sec. 34, T. 22 S., R. 6 E., approx. 2,500' from W line, 1,900'
from N line of section

Lat 38°51'39" N., long 111°14'01" W.

76.0-77.45: ss, f- to med-gr; lots of coal fragments; sharp basal contact

77.45-92.2: C coal bed

83.9-85.2 tonstein ("thick"); sharp lower grad upper contact

tonstein 0.1 @ 87.45 (upper member of "doublet"); diffuse in coal

tonstein 0.1 @ 87.95 (upper member of "doublet"); diffuse in coal

tonstein 0.15 @ 89.75 ("lower"); diffuse in coal

92.2-93.0: sltst; rooted

93.0-95.9: ss, vf-gr, slty; rooted in upper part; soft-sed deformation

TD 95.9

Q-7 SE 1/4 sec. 3, T. 23 S., R. 6 E. approximately 200' from E line,
1,000' from S line of section

Lat 38°50'26" N., long 111°13'27" W.

70.3-74.5: sltst with lam of clyst; heavily bioturbated; grad lower
contact

74.5-75.8: clyst, slty with sltst lam in upper part; a few coaly streaks
in lower part; bioturbated

75.8-76.5: sh, carb with coal bands, about 50% coal
(70.3-76.5 represents a brackish-water bay-fill sequence)

76.5-83.6: I coal bed; bands of pyrite in uppermost 2'

83.6-83.8: sh and sltst, both carb

83.8-84.9: ss, vf-gr, rooted

(interval 84.9-180.0 rotary drilled)

180.0-182.7: clyst, slty and sltst; a few thin beds of vf-gr to f-gr ss

182.7-183.6: ss, med-gr; abundant coal frags; sharp basal contact

(180.0-183.6 represents an abandoned channel-fill, the med-gr ss being the basal lag deposit)

183.6-194.9: ss, vf-gr with lam of sltst and sltst; some of the ss displays ripple-drift x-lam; some rooting; entire interval moderately bioturbated; finely-divided plant frags

194.9-195.7: clyst

195.7-196.4: sh and clyst, carb

196.4-197.3: coal (rider of C coal bed)

197.3-197.6: sh, coaly

197.6-199.4: sltst; rooted; grad lower contact

199.4-199.9: ss, f-gr, very cly

199.9-201.3: sh, carb; ss-filled burrows near top

201.3-202.9: sh, coaly; crumbly

202.9-204.8: clyst, carb

(183.6-204.8 represents deposits of a brackish-water bay of the delta-plain environment)

204.8-224.6: C coal bed

204.8-209.3 shaley coal

tonstein 0.1 @ 209.35

tonstein 0.1 @ 211.25; diffuse in coal

tonstein 0.1 @ 211.85; diffuse in coal

tonstein 0.3 @ 213.6

sh, carb 0.1 @ 216.5

tonstein 0.05 @ 216.6

216.7-217.6 clyst

tonstein 0.3 @ 221.2 (probably "lower"); diffuse in coal

224.6-226.8: ss, vf- to f-gr; carb, dark brown to black; rooted

226.8-232.8: ss, f-gr; rooted in upper part

TD 232.8

Q-8 SW 1/4 sec. 35, T. 22 S., R. 6 E. approx 900' from W line, 100' from
S line of section

Lat 38°51'08" N., long 111°13'12" W.

76.0-90.9: ss, f- to med-gr; x-bedded; sharp lower contact (basal part
of No. 4 delta-front sandstone; no transgressive lag deposit
developed in this area)

90.9-91.9: sh, carb

91.9-106.7: C coal bed

97.2-98.7 tonstein ("thick"); sharp basal, grad upper contact
tonstein 0.1 @ 100.85 (upper member of "doublet"); diffuse in coal
tonstein 0.1 @ 101.4 (lower member of "doublet");
diffuse in coal
tonstein? 0.3 @ 103.4 (lower member of "doublet"?)

106.7-109.2: clyst

109.2-111.9: sltst and slty clyst; soft-sed deformation

TD 111.9

Q-9 NW 1/4 sec. 35, T. 22 S., R. 6 E.

approx 1,100' from W. line, 300' from N. line of section

Lat 38°51'53" N., long 111°13'10" W.

110.0-141.6: ss, f- to med-gr; planar-lam in upper part, otherwise all
heavily burrowed, the intensity of burrowing increasing

downward; abundant finely divided plant frags, increasing in size to frags of coal in lower part; sharp basal contact (lower part of No. 4 delta-front sandstone; transgressive lag deposit cannot be separated from the rest of the No. 4 ss in the core--is probably represented by lowermost approx. 2' of ss, which is more heavily burrowed than the rest)

141.6-153.3: C coal bed

145.0-146.1 tonstein ("thick"); sharp basal, grad upper contact

tonstein 0.1 @ 148.3 (upper member of "doublet")

tonstein 0.1 @ 148.65 (lower member of "doublet")

tonstein 0.25 @ 150.9 ("lower")

153.3-153.8: sltst, carb; rooted

153.8-154.7: clyst, slty

154.7-157.7: sltst, cly

TD 157.7

Q-10 NE 1/4 sec. 27, T. 22 S., R. 6 E. approx. 1,100' from E line, 800' from N line of section

twins M-5

Lat 38°52'42" N., long 111°13'39" W.

76.0-78.7: ss, f-gr; contains coal frags, one of which includes small (approx. 1 mm) ss-filled borings that are probably small Teredolithus (basal part of active channel-fill)

78.7-103.6: I coal bed; ss-filled burrow at top; lenses of vf-gr ss at bottom (burrows at top of coal indicate that original marine or brackish-water strata overlying coal were removed and replaced by the fluvial channel deposits)
tonstein 0.2 @ 82.8

tonstein 0.1 @ 90.1

carb sh 0.03 @ 91.75

103.6-105.0: ss, vf-gr, slty with contorted lam of sltst; coal frags; rooted
TD 180'

Hole abandoned due to dangerously high levels of H₂S gas produced with water
from depths of approximately 160' to 180'. Drager tester sampling gas from
just below Kelley bushing gave reading of 45.

Q-10a NW 1/4 sec. 26, T. 22 S., R. 6 E., hole located right in NW corner
of section, within 50' of N and W lines of section; same location
as M-6.

Lat 38°52'50" N., long 111°13'24" W.

230.0-239.0: ss, vf- to f-gr; heavily bioturbated

239.0-242.9: ss, vf- to f-gr; very heavily bioturbated, many Chondrites;
frags of coal; sharp basal contact (transgressive lag deposit
associated with overlying No. 4 delta-front sandstone)

242.9-254.9: C coal bed

246.75-247.85 tonstein ("thick"); grad upper, sharp lower contact

tonstein 0.1 @ 249.9 (upper member of "doublet")

tonstein 0.1 @ 250.25 (lower member of "doublet")

tonstein 0.3 @ 252.85 ("lower")

254.9-255.3: sh, carb

255.3-256.9: clyst

TD 256.9

Q-11 NE 1/4 sec. 23, T. 22 S., R. 6 E. approx 1,000' from E line, 900' from
N line of section; upper part twins M-9.

Lat 38°53'34" N., long 111°12'30" W.

35.0-36.5: ss, vf-gr; x-bedded in upper part (wave-dominated shallow-marine sandstone)

36.5-37.1: lost core; probably more ss as above; may have lost top of coal bed

37.1-41.95: J coal bed
tonstein 0.05 @ 37.25
pyrite band 0.05 @ 41.15

41.95-42.25: clyst

42.25-43.3: sltst, cly

43.3-50.2: upward coarsening sequence, sltst to vf-gr slty ss; heavily burrowed (brackish-water bay-fill sequence)

50.2-51.9: coal with carb sh lenses and ss-filled burrows; approx. 50% coal; pyrite band 0.1 @ 51.0

51.9-52.4: sltst, shly with bands of coal

52.4-59.5: upward coarsening bay-fill sequence as described above; coal lenses at bottom

59.5-60.2: coal, badly broken up

60.2-60.6: sltst, cly; grad lower contact

60.6-79.4: ss, vf-gr interlam and interbedded in some parts with sltst; ss shows ripple-drift x-lam and minor x-bedding; burrows common at several levels; some soft-sed deformation; finely divided plant frags and sltst rip-ups common (sequence records deposition in a brackish-water bay in the delta plain environment)

79.4-80.9: ss, med- to c-gr; sharp lower contact (possibly a lag deposit formed as the shoreline of the bay transgressed southwestward across the underlying swamp deposits)

80.9-82.4: coal (subseam of I coal bed)

82.4-82.6: sh, carb

(interval 82.6-190.8 rotary drilled)

- 190.8-209.5: interlaminated and interbedded vf-gr ss and sltst; entire sequence moderately bioturbated -- Thalassinoides is the common burrow form, with minor Teichichnus; coal frags in lowermost 1'
- 209.5-221.2: C coal bed
- 209.85-211.2 tonstein ("thick"); grad upper, sharp lower contact; lower part soft, flakey
- possible tonstein 0.45 @ 215.9 (if tonstein, probably the "lower" one)
- 217.4-220.1: clyst, crumbly
- 221.2-221.7: clyst, slty, carb
- 221.7-222.4: sh, carb and coaly, slty in lower part
- 222.4-223.1: sltst, carb; rooted
- 223.1-225.6: sltst, sdy, grading downward to vf-gr slty ss; contorted clyst lam
- TD 225.6
- Q-12 SW 1/4 sec. 12, T. 22 S., R. 6 E., approx. 1,800' from W line, 900' from S line of section
- Lat 38°54'46" N., long 111°11'54" W.
- Core begins in coal--coring point picked too low. Probably no more than a few tenths of a foot of coal was lost to drilling
- 280.0-291.5: C coal bed; all of the coal is shly
- carb sh 0.3 @ 280.8
- 280.8-282.4 tonstein ("thick")
- tonstein 0.25 @ 287.9
- 289.3-290.3 coaly sh
- 291.5-291.8: sh, carb; band of vitrinite at base
- 291.8-292.2: sh, slty

292.2-292.9: sltst, rooted

TD 292.9

Q-13 SE 1/4 sec. 1, T. 22 S., R. 6 E., approx. 1,400' from E line, 1,500'
from S line of section; twins drill hole EN-1
Lat 38°55'44" N., long 111°11'29" W.

375.0-384.0: sltst, cly; hard; sdy in lowermost 0.4'; contains Baculites sp.,
Inoceramus sp. (possibly the early Coniacian species Inoceramus
waltersdorfensis Andert) and other unidentified bivalves (basal
part of Blue Gate Shale Member of Mancos Shale)

384.0-386.4: shly coal and coaly sh; contains many streaks of pyrite weathering
to yellow jarosite

386.4-386.9: sh, carb

386.9-389.3: sltst, cly, grading downward to slty clyst; lam and lenses of
vf-gr ss; finely-divided plant frags; soft-sed deformation; a
few possible small burrows

389.3-392.5: coal, becoming shly towards base

392.5-393.0: sh, carb to coaly, sdy
(384.0-393.0 represents the zone of the J coal bed)

393.0-402.5: ss, f-gr; rooted at top; faint x-bedding near bottom
(top part of wave-dominated shallow-marine sandstone unit)
(interval 402.5-610.0 rotary drilled)

610.0-615.6: sltst with lam and beds up to 0.6' thick of vf-gr ss; ss
planar lam and moderately bioturbated; minor finely divided
plant frags; lower contact sharp (prodelta deposits of No. 4
delta cycle)

615.6-619.2: ss, f-gr; upper half moderately bioturbated, all Ophiomorpha,
with minor finely divided plant frags; lower half heavily

burrowed with lots of coal frags; basal contact sharp
(transgressive lag deposit)

619.2-620.6: sh, coaly

620.6-630.9: C coal bed; most of the coal is shly

620.7-622.1 tonstein ("thick"); grad. upper, sharp lower contact; vf-gr, no
crystals visible except at bottom

tonstein 0.05 @ 624.0 (upper member of "doublet")

tonstein 0.1 @ 624.65 (lower member of "doublet")

tonstein 0.1 @ 627.5 ("lower")

630.9-633.6: clyst, slty in lower part; grad lower contact

633.6-636.2: sltst, carb in upper part; coal lenses; rooted in upper part

636.2-642.5: sltst, interbedded with vf-gr ss, ss making up approx. 30%;
moderately to heavily burrowed

642.5-643.7: ss, f-gr with lam and rip-ups of sltst and coal frags;
moderately burrowed

TD 643.7

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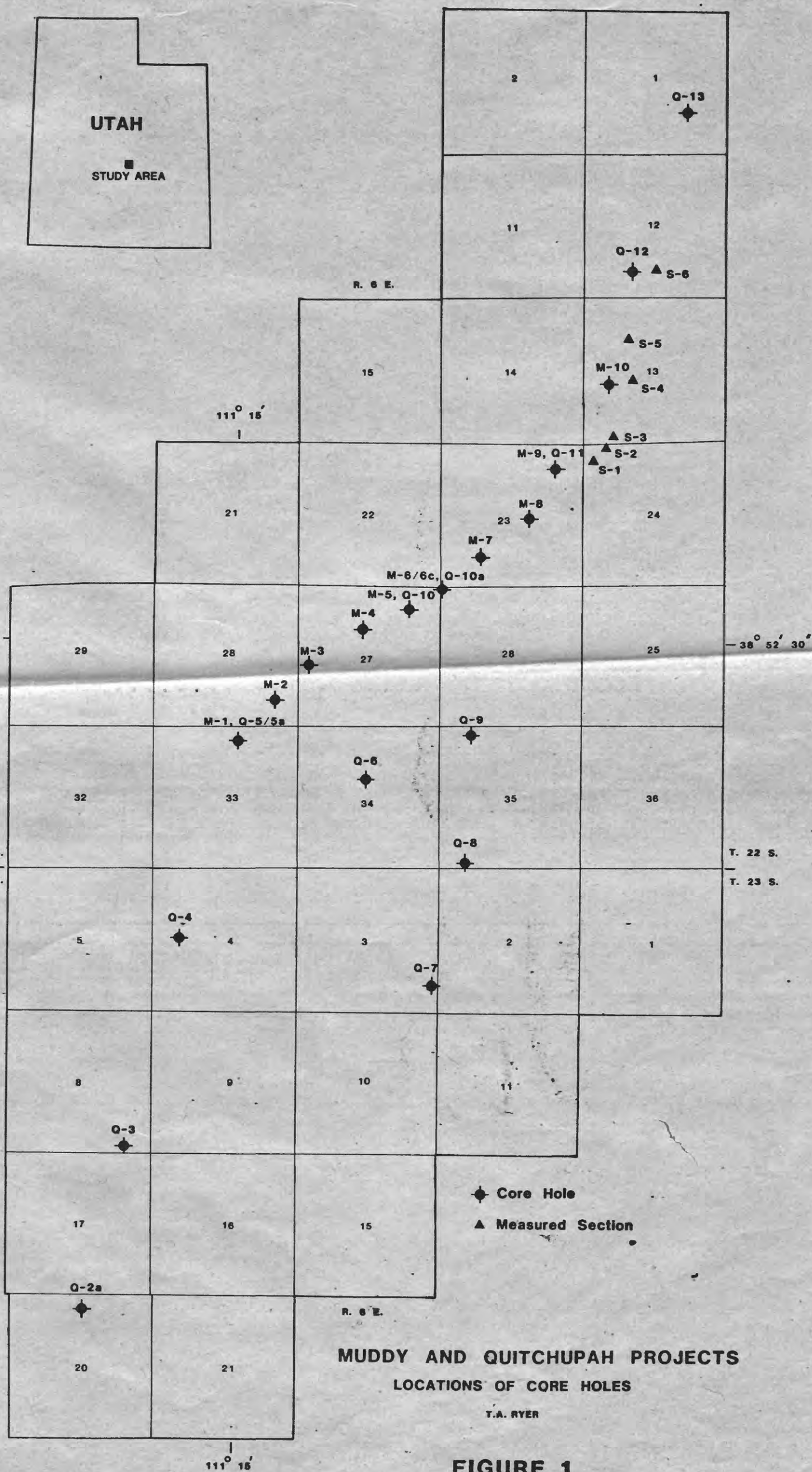
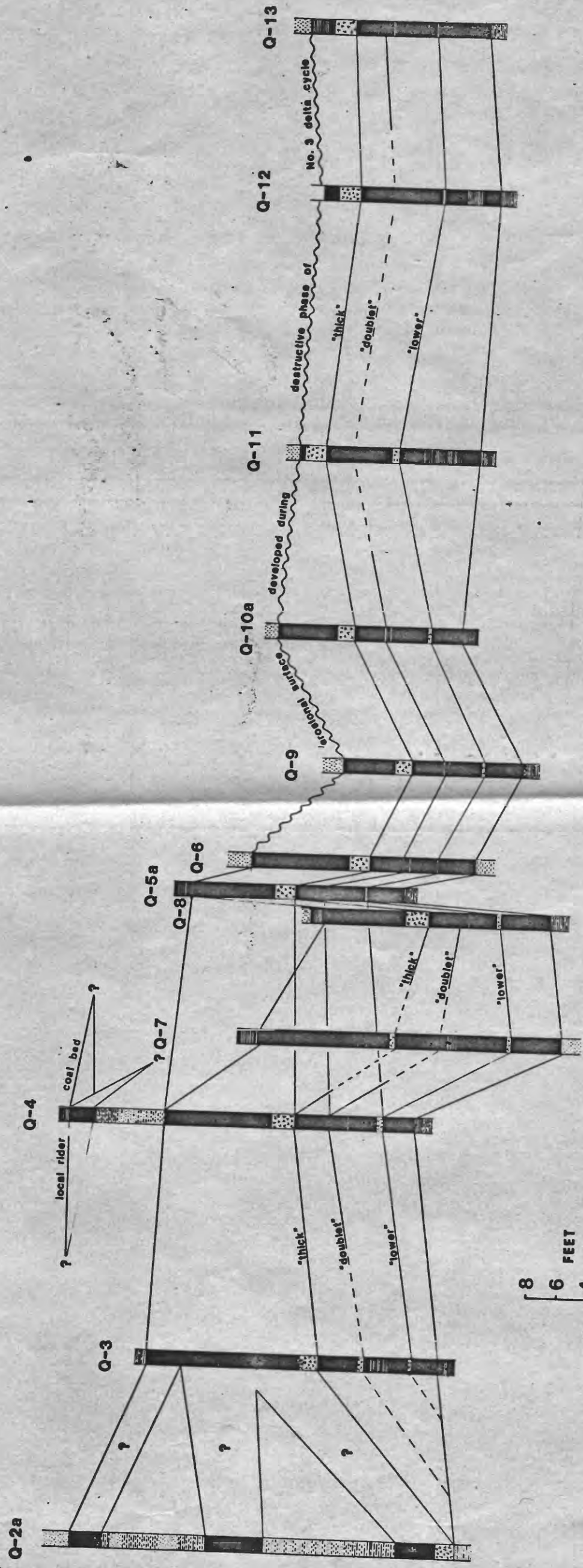


FIGURE 1

81-460

81-460



QUITCHUPAH PROJECT
CORRELATION OF CORES OF C COAL BED
vertical exaggeration 1,000 times

T. A. RYER

FIGURE 2

81-460

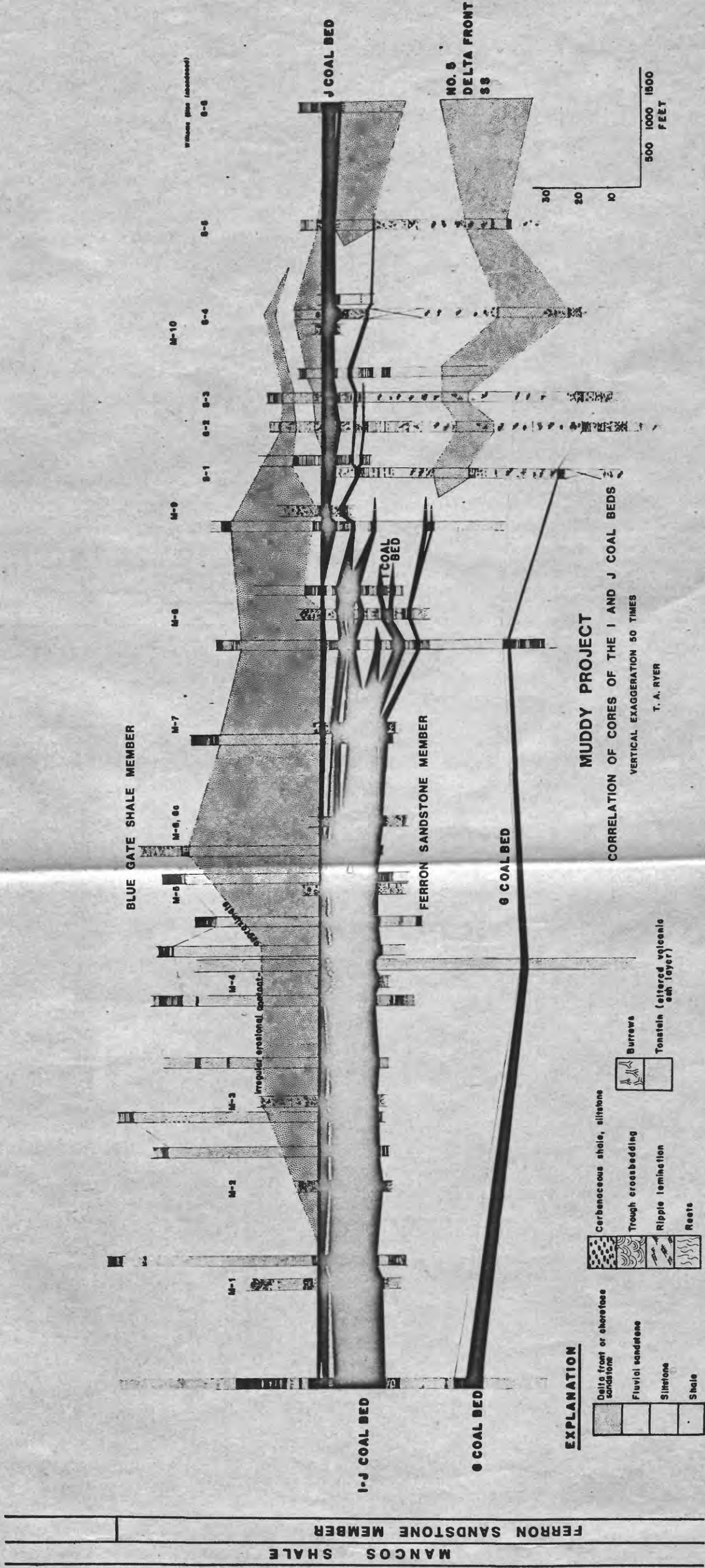


FIGURE 3